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Evaluation of basic items for evauation of thermal specifications of oil

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ABSTRACT

In this paper, the tests are designed for investigation of the effects of the synthesized oxide zinc nano particle prepared by ultrasonic on the crude oil flowing properties. Rheological and thermal properties of crude oil with nano particle are surveyed, experimentally. When temperature increases from 15 C to 25 C, the heat capacity increases from 0.475 to 0.481 BTU/lb.F (with adding nano particles). Range of variation oh heat capacity is from 0.47 to 0.478 BTU/lb.F (with adding nano particles). This range of temperature decreases the density value for nano oil (1 wt%) and simple oil to 0.93 and 0.929 of the initial value, respectively.

KEYWORDS

Thermal properties;
Temperature;
Velocity;
Nano.

INTRODUCTION

Crude oil

Crude oil, liquid petroleum that is found accumulated in various porous rock formations in Earth's crust and is extracted for burning as fuel or for processing into chemical products[1]. Although it is often called "black gold," crude oil has ranging viscosity and can vary in color to various shades of black and yellow depending on its hydrocarbon composition[2]. Undoubtedly, crude oil is one of the powerful sources of energy provision in the world.

Access to oil was and still is a major factor in several military conflicts of the twentieth century, including World War II, during which oil facilities were a major strategic asset and were extensively bombed. The German invasion of the Soviet Union included the goal to capture the Baku oilfields, as it would provide much needed oil-supplies for the German military which was suffering from blockades. Oil exploration in North America during the early 20th century later led to the US becoming the leading producer by mid-century. As petroleum production in the US peaked during the 1960s, however, the United States was surpassed by Saudi Arabia and the Soviet Union[3].

Today, about 90 percent of vehicular fuel needs are met by oil[4]. Petroleum also makes up 40 percent of total energy consumption in the United States, but is responsible for only 1 percent of electricity generation. Petroleum's worth as a portable, dense energy source powering the vast majority of vehicles and as the base of many industrial chemicals makes it one of the world's most important commodities[5]. Viability of the oil commodity is controlled by several key parameters, number of vehicles in the world competing for fuel, quantity of oil exported to the world market (Export Land Model), Net Energy Gain (economically useful energy provided minus energy consumed), political stability of oil exporting nations and ability to defend oil supply lines[6,7].

The top three oil producing countries are Russia, Saudi Arabia and the United States. About 80 percent of the world's readily accessible reserves are located in the Middle East, with 62.5 percent coming from the Arab 5: Saudi Arabia, UAE, Iraq, Qatar and Kuwait. A large portion of the world's total oil exists as unconventional sources, such as bitumen in Canada and extra heavy oil in Venezuela. While significant volumes of oil are extracted from oil sands, particularly in Canada, logistical and technical hurdles remain, as oil extraction requires large amounts of heat and water, making its net energy content quite low relative to conventional crude oil. Thus, Canada's oil sands are not expected to provide more than a few million barrels per day in the foreseeable future[8,9].

In its strictest sense, petroleum includes only crude oil, but in common usage it includes all liquid, gaseous, and solid hydrocarbons[10]. Under surface pressure and temperature conditions, lighter hydrocarbons methane, ethane, propane and butane occur as gases, while pentane and heavier ones are in the form of liquids or solids[11]. However, in an underground oil reservoir the proportions of gas, liquid, and solid depend on subsurface conditions and on the phase diagram of the petroleum mixture[12].

An oil well produces predominantly crude oil, with some natural gas dissolved in it. Because the pressure is lower at the surface than underground, some of the gas will come out of solution and be recovered (or burned) as associated gas or solution gas. A gas well produces predominantly natural gas[13]. However, because the underground temperature and pressure are higher than at the surface, the gas may contain heavier hydrocarbons such as pentane, hexane, and heptane in the gaseous state. At surface conditions these will condense out of the gas to form natural gas condensate, often shortened to condensate[14]. Condensate resembles petrol in appearance and is similar in composition to some volatile light crude oils.

The proportion of light hydrocarbons in the petroleum mixture varies greatly among different oil fields, ranging from as much as 97 percent by weight in the lighter oils to as little as 50 percent in the heavier oils and bitumens[15].

The hydrocarbons in crude oil are mostly alkanes, cycloalkanes and various aromatic hydrocarbons while the other organic compounds contain nitrogen, oxygen and sulfur, and trace amounts of metals such as iron, nickel, copper and vanadium[16].

Nanotechnology

In recent years, development in the miniaturization technologies results in fabrication of micro-scale electronic devices which is used in various industries such as aerospace and automotive. For maximum performance of these micro devices which is known as MEMS (Micro Electromechanical Systems), the temperatures should be in a certain range. Micro channel as Compact and efficient cooling devices have been developed for the thermal control of MEMS[18]. Utilizing nano fluid as working fluid could improve the cooling and heating performance. Because of more stable nature of nano fluid compared with its pioneer generation (including micro and millimeter particles) and exceptional thermal conductivity of nanoparticles, it could considerably enhance the convective heat transfer coefficient in micro channel. During the last decade, many studies on convective heat transfer with nano fluids have been considered[19].

MATERIALS AND METHOD

Preparing nano-sized ZnO

Zinc dioxide (ZnO) is a transition metal oxide that has long been known to be active for hydrocarbon decomposition and has more recently shown to display high reforming activity for various long-chain Hydrocarbons. Researches showed that ZnO is highly active for reforming isooctane via partial oxidation. This process is exothermic ($\Delta H° = -659.9$ kJ/mol) and in the presence of ZnO proceeds to full conversion at 700°C and 1 atm. The catalytic activity shown by ZnO can be explained in terms of the Mars-van Krevelen mechanism, which involves the consumption of nucleo philic oxygen ions provided by the oxygen sub-lattice with the purpose of sustaining the redox cycles taking place on the catalyst surface. Despite its interesting catalytic properties, a very limited number of studies have been conducted examining the potential of ZnO as a catalyst for reforming processes. Such studies were carried out using commercial ZnO, with particle sizes in the range of a few micrometres and Brunauer, Emmett, and Teller (BET) surface areas <10 m2/g. By utilizing nanoparticles we have shown that it is possible to significantly increase the total reactive surface area and thus achieve reforming processes with much higher efficiency levels than those of commercial ZnO. Nanoparticle ZnO was synthesized by reduction of zinc trioxide (MoO3) powder in a 1:3 volume ratio of ethylene glycol to distilled water16. The mixture was combined in a 45 ml Teflon-lined general-purpose vessel, which was subsequently sealed and heated to 180°C for 12h. After cooling, the dark colored ZnO was filtered and air dried at 100°C.

Experimental set up

The experimental set up includes mixing tank, adiabatic tube test section and electrical heater is used to survey the behavior of nano crude oil. At the beginning, the crude oil is mixed by zinc oxidenano particles in a ultrasonic (With 400Watt, for 3hour), then the nano crude oil is mixed in mixing tank, passing through an electrical heater to reach the desired temperature in range of, 30 C to 90 C and 25 C to 85 C. Vertical adiabatic test tube with 0.3 m and 0.025 m in length and diameter, respectively is used. Digital sensors transmit the obtaining parameters to the control box. Finally, nano crude oil is collected in a tank. All parameters are obtained with one type of crude oil then all the setup is drained and washed with water stream injection from water inlet port located in mixing tank.

RESULTS AND DISCUSSION

Experiments are held to investigate the properties and behavior of nano oil comparing with simple oil. Thermo-physical properties like density, viscosity, thermal conductivity, thermal diffusivity with changes in temperature and amount of nano particle are surveyed.

Figure 1 shows the heat capacity increasing with increasing the temperature. According to the Figure 1, when the temperature increases from 15 C to 25 C, the heat capacity increases from 0.475 to 0.481 BTU/lb.F (with adding nano particles). Range of variation oh heat capacity is from 0.47 to 0.478 BTU/lb.F (with adding nano particles).

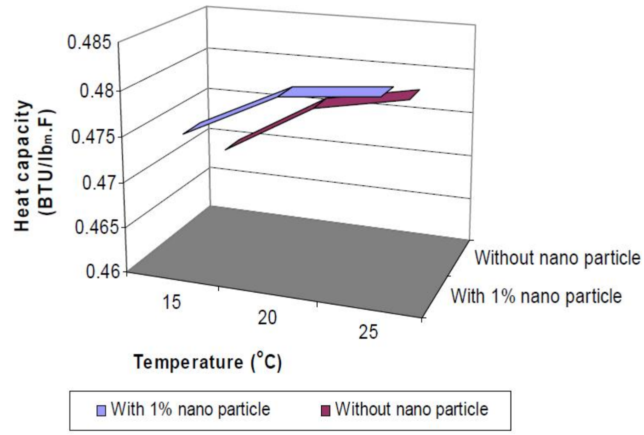

Figure 1 : The effect of temperature on heat capacity

Figure 2 illustrates the effect of temperature on the velocity values. The velocity values increasing from 1.69 to 1.78 meter per second (with nano particles). These values for velocity is 1.61 to 1.68 meter per second (in without nano particles state).

Values of conductive heat transfer coefficient of nano oil with 1% nano zinc are compared with those values for simple oil in Figure 3. The results for nano oil are higher than those are obtained for simple oil at the same value of temperature. Obviously, one kind of average thermal conductivity value of oil and particles obtain the thermal conductivity value of nano oil. Nano zinc solid particles have higher values of thermal conductivities than liquid oil at the same temperature, so the higher values of thermal conductivity (11.4%) of nano oil are obtained than simple oil at the same temperature. Also, the effect of temperature is shown for both simple and nano oil in Figure 3. Temperature changes in values of 30, 50, 70 and 90 C show the ranges of 1.25 (W/m.C) to 1.41 (W/m.C) for nano oil (1 wt%) and 1.14 (W/m.C) to 1.26 (W/m.C) for simple oil. The higher values of temperature results the higher

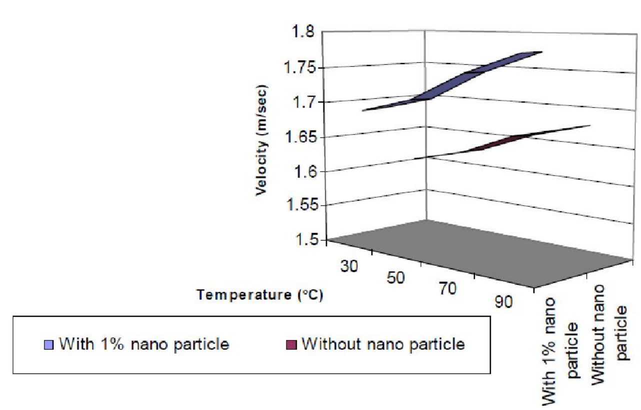

Figure 2 : The effect of temperature on the velocity

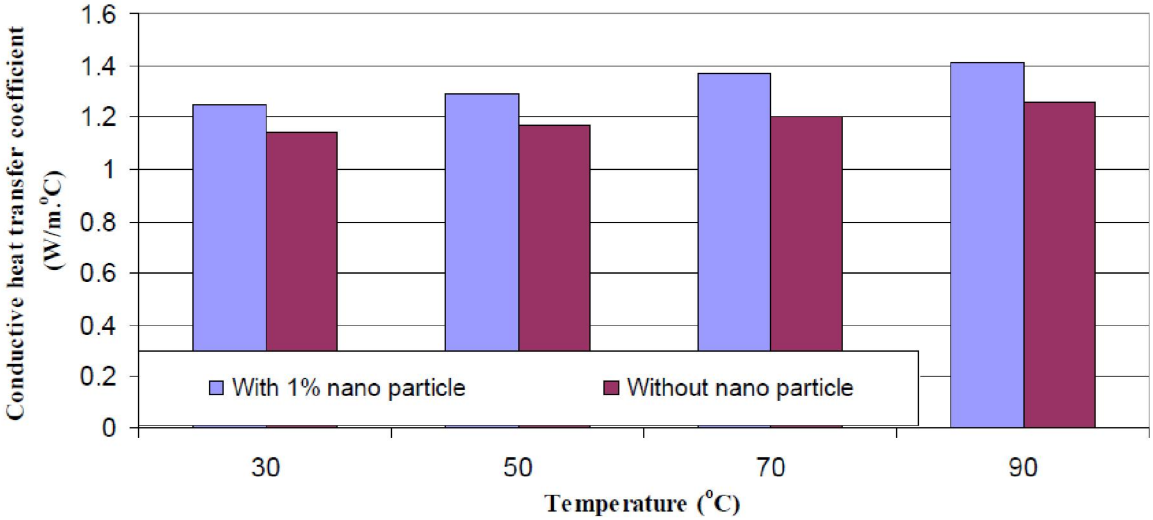

Figure 3 : Values of conductive heat transfer coefficient versus temperature

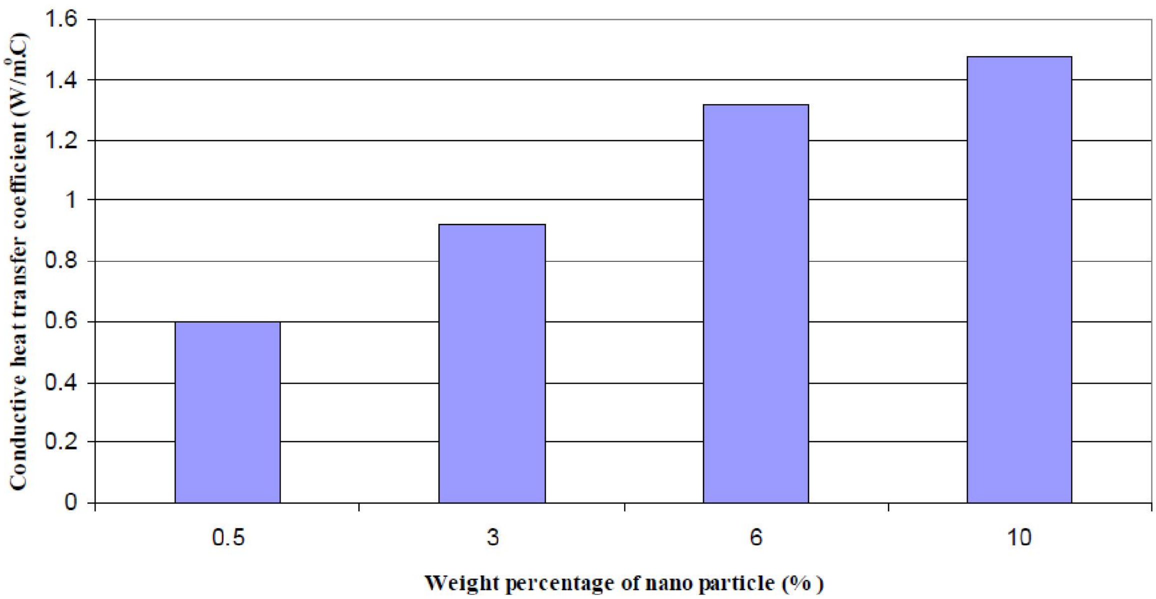

Figure 4 : Conductive coefficient factor versus amount of nano particle

values of conductive heat transfer coefficients for both simple oil and nano oil. This may be related to the higher kinetic energy of nano zinc particles on the higher values of temperatures which increases the nano oil conductive heat transfer coefficient.

Effect of amounts of nano particle in weight percent on the amounts of conductive coefficient is shown in Figure 4. The increase in the amounts of nano particle in weight percent from 0.5% to 10% increases the values of conductive coefficient factor from 0.6 (W/m.K) to 1.48 (W/m.K). However the rate of increase in the amounts of conductive coefficient decreases when the weight percent of nano particle increases from 7% to 11%.

CONCLUSIONS

Application of nano zinc oxide in oil is studied in this manuscript. The effect of addition of different weight percentage of nano particle into the oil which flows vertically under different temperatures (ranges from 30-70 C, 25- 85 C, 30- 90 C) in a tube section is investigated, experimentally. Some important thermo-physical properties are measured. Besides, some applicable dimensionless groups in hydrodynamic calculations and heat transfer are presented. The increase in temperature from 30 C to 90 C increases the values of conductive heat transfer coefficient 1.13

times and 1.1 times for nano oil (1 wt%) and simple oil, respectively. This range of temperature decreases the density value for nano oil (1 wt%) and simple oil to 0.93 and 0.929 of the initial value, respectively. Through the length of tube section the increase in amounts of velocity and heat capacity is obtained for both simple oil and nano oil contains 1 wt% nano zinc oxide.

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